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Original Research

Optic nerve sheath diameter for monitorization during coronary bypass surgery

Optic nerve sheath diameter

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Abstract

Aim: Coronary artery bypass surgery (CABG) is a life-saving treatment for coronary artery diseases. Optic nerve sheath diameter (ONSD) measurement by ultrasonography is a non-invasive, safe, and quick method for identifying increased intracranial pressure (ICP) induced by CABG surgery. In this study, we aimed to demonstrate ONSD variation during the course of CABG surgery.

Materials and Methods: Fifty patients over 18 years of age and scheduled for CABG surgery were prospectively enrolled. Traditional CABG surgery was performed on all patients diagnosed with coronary artery disease. Consecutive ultrasound examinations to the closed eyelids were performed before surgery, after intubation, 15 minutes after cross-clamping, after displacement of cross-clamping, and at the end of the operation.

Results: The patients' mean age was 62.2±6.9 years, and 80% (n=40) were male. Mean ONSDs at all stages of the surgery were statistically significantly higher than the mean basal measurement values. Mean arterial pressure was significantly lower after intubation and at the end of the surgery ($p<0.001$ for both), while heart rate was higher than basal levels at both time points (p=0.02 and 0.003, respectively). No significant perioperative complications were observed.

Discussion: ONSD increases in a linear fashion as ICP increases. Similarly, a step-by-step increment in OSND was observed until the end of CABG surgery, which was thought to reflect the result of the operation on ICP in this study. OSND diameters greater than 5.5 mm predict an ICP of ≥20 cm H2O with 100% sensitivity and specificity, but this limit was not reached in any of the phases in this study. Our results show that measurement of OSND is a promising predictor of increased ICP in CABG surgery. It can help to predict hemodynamic instability and complications during coronary bypass surgery, which can be further used as a part of monitorization during CABG surgeries.

Keywords

Coronary Artery; Bypass Surgery; Intracranial pressure; Optic Nerve Sheath Diameter

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Introduction

Coronary artery disease (CAD) is one of the main causes of death in the adult population. It usually results from a build-up of plaque in major blood vessels of the heart and affects millions of individuals globally. World Health Organization and Turkish Statistician Institution reports reveal that complications, such as angina, myocardial infarction, heart failure, and arrhythmias, are not unusual. Coronary artery bypass surgery (CABG) is a life-saving, widely used treatment strategy, together with percutaneous coronary interventions and stenting, for supplying revascularization [1].

CABG surgery has been increasingly performed in recent years. Ideally, it should increase the coronary flow reserve without raising early or late morbidity and mortality. Nevertheless, CABG surgery is a high-risk procedure with a 30-day morbidity rate of 14% and mortality rate of 2% [2]. Perioperative complications including prolonged intubation, infection risk, myocardial infarction, renal failure, and low cardiac output syndrome may occur. Cerebral injury is also a frequent complication, one associated with high hospital costs, increased likelihood of readmission to hospital after discharge, and impaired quality of life [3]. An imbalance between mean arterial pressure (MAP) and cerebral perfusion pressure results in increased intracranial pressure (ICP). It is therefore essential to monitor the effects of CABG on the body in order to reduce accompanying morbidities and mortality.

Measurement of the optic nerve sheath diameter (ONSD) is a promising method for reflecting ICP. The optic nerve is covered by a sheath composed of meninges and reflects intracranial and intraorbital pressure changes due to cerebrospinal fluid (CSF) circulation [4]. In contrast to other modalities, ONSD measurement by ultrasonography has been proposed as a non-invasive, radiation-free, safe, and rapid method for identifying increased ICP. Its diagnostic accuracy has been tested in various patient groups with various types of surgery, trauma, diabetes, hypertension, and stroke [5-10].

The goals of this study were to demonstrate ONSD variation during the course of CABG surgery.

Material and Methods

Fifty patients over 18 years of age and scheduled for CABG surgery at the Erzurum Regional Training and Research Hospital, Turkey, between January 1, 2016 and December 31,2017, were prospectively enrolled. The study was approved by the local ethical committee, and written informed consent was obtained from all patients preoperatively.

Traditional CABG surgery was performed on all patients diagnosed with CAD. Following median sternotomy, on-pump revascularization was performed under general anesthesia. The majority of patients underwent a standard procedure involving the use of the left internal mammary artery to the left anterior descending artery and of the saphenous veins to the remaining coronary arteries. Single grafting was sometimes performed, while sequential bypass and complex configurations were used in a minority of patients due to inadequate venous grafts [1].

MAP and heart rate were recorded. Ultrasound examinations were conducted to the closed right and left eyelids with the patient in a supine position. During the procedure, a linear array ultrasound transducer plus sterile gel were used 3 mm posterior to the globe for each eye. Examinations were performed immediately before surgery, after intubation, 15 minutes after cross-clamping, after displacement of cross-clamping, and at the end of the operation.

Patients younger than 18, with ophthalmological diseases capable of affecting optic nerve diameters, or receiving any treatment affecting cerebrospinal fluid pressure, together with pregnant women, were excluded.

Descriptive statistics were expressed as mean, standard deviation, median, minimum, and maximum values. Distribution of data was evaluated using the Kolmogorov–Smirnov test. Dependent quantitative data were analyzed using the Wilcoxon test. IBM SPSS 20.0 software was used during analyses.

Results

Fifty patients with a mean age of 62.2±6.9 years were included. Eighty percent (n=40) of patients were men. All patients had ASA III scores. Subjects' underlying diseases and perioperative characteristics are shown in Table 1. Only 18% of patients had known CAD before CABG surgery. Noradrenaline was the most frequently used inotropic agent.

Mean ONSDs at all stages during surgery were statistically significantly higher than the mean basal measurement (Figure 1). Hemodynamic parameters are shown in Table 2. MAP was significantly lower after intubation and at the end of the operation ($p<0.001$ for each), and heart rate was similarly higher than basal levels at both time intervals ($p=0.02$ and 0.003, respectively). No significant perioperative complications were observed.

Table 1. Properties of patients undergoing coronary bypass surgery

Underlying diseases of the patients	
Hypertension, n (%)	15 (30)
Diabetes mellitus, n (%)	14 (28)
Coronary artery disease, n (%)	9 (18)
Chronic obstructive pulmonary disease, n (%)	5 (10)
The perioperative properties of the patients	
Need of noradrenaline, n (%)	45 (90)
Need of dopamine, n (%)	43 (86)
Need of adrenaline, n (%)	0 (0)
Need of glyceryl trinitrate, n (%)	0 (0)

SD, standard deviation

Table 2. Comparison of parameters of patients undergoing coronary bypass surgery with respect to basal measurements

Measurement time	Mean arterial pressure (mmHg) (mean ± SD)	p value
Basal measurement[V]	97.1 ± 12.1	
After intubation	89.3 ± 10.9	0.001
At the end of the operation	86.8 ± 13.9	0.001
	Heart rate (bets/min) (mean ± SD)	
Basal measurement[V]	79.5 ± 14.2	
After intubation	85.4 ± 11.3	0.02
At the end of the operation	89.4 ± 14.2	0.003

V, measurement before the beginning of anesthesia; SD, standard deviation

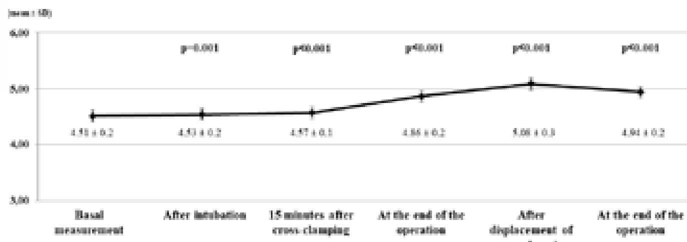

Figure 1. Measurement of optic nerve sheath diameters (ONSD) of patients undergoing coronary bypass surgery with respect to basal measurement

Discussion

ONSD increases in a linear fashion as ICP increases [11]. Similarly, we observed a step-by-step increment in OSND until the end of CABG surgery, which we think reflected the result of this operation on ICP. Space-occupying lesions, increased CSF production, decreased CSF reabsorption, or increased blood volume due to a variety of causes can all raise intracranial pressure. Cerebral injury secondary to CABG surgery occurs through cerebral embolism and hypoperfusion, atherosclerosis of the aorta, and lipid embolism in cerebral microvessels [3]. Normally, ICP may increase gradually throughout surgery, but it has been suggested that the value should remain at ≤15 mmHg [12]. A typical optic nerve sheath is generally less than 5 mm in diameter, and diameters greater than 5.5 mm predict an ICP of ≥20 cm H_2O with 100% sensitivity and specificity [13]. This limit was not reached in any of the phases in this study. Changes in ONSD during cardiac surgery can also be related to volume status fluctuations, and measuring ONSD can, therefore, provide an estimation of cerebral edema as well as malposition of intravascular catheters [14].

Increased ICP should be recognized and managed immediately in order to avoid sequelae and even death. Measurement of ICP has been recommended using direct ventriculostomy, lumbar puncture, computed tomography (CT), or magnetic resonance imaging (MRI). However, some of these may cause difficulties in hemodynamically unstable patients, and some require skilled personnel or trained neurosurgeons to perform, in addition to risks of damage of brain tissues, infection, and bleeding, and lower reliability rates [11]. Portable ultrasound is readily available, and ONSD measurement by ultrasonography is a non-invasive, harmless, and rapid method that can also be easily performed by non-radiologists. It is additionally beneficial when direct ICP monitoring is contraindicated or unavailable.

CABG surgery has been successfully performed since 1960 [15]. It prolongs life expectancy and improves the quality of the life of patients with CADs and related disorders, as in our study population. Hemodynamic alteration occurs during the procedure. A decline in cardiac performance occurs because of increased pulmonary and systemic afterload and decreased myocardial contractility. Arterial resistance and MAP decrease, and compensatory tachycardia occurs. Similarly, in this study, decreased MAP and tachycardia were seen during the procedure, and inotropic agents were required. Cerebral perfusion decreases even with a normal MAP, and eventual hypotension occurs as a result of reduced oxygen delivery [12]. Several neurological manifestations, such as stroke, encephalopathy, and neurocognitive dysfunction can occur, but these are beyond the scope of this study [16].

Although this is one of the few studies to evaluate ultrasonographic ONSD measurement in CABG surgery patients, our research has some limitations. First, it was a single-center study with a limited number of patients. It would also have been more valuable if MAP and heart rate values could have been correlated with ONSD values at each time point. The absence of confirmatory ICP values may be another limitation since this is one of the first studies in this patient group.

In conclusion, ultrasonographic measurement of ONSD is a highly practical, rapid, harmless, easily available, and non-invasive method. Our results show that measurement of OSND is a promising predictor of increased ICP in CABG surgery patients. It can help to predict hemodynamic instability and complications during coronary bypass surgery, which can be further used as a part of monitorization during CABG surgery.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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